Sensitivity Mapping of Inland Areas: Technical Support to the Inland Area Planning Committee Working Group USEPA Region 5

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Sensitivity Mapping of Inland Areas: Technical Support to the Inland Area Planning Committee Working Group USEPA Region 5

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1 INTRODUCTION

The Oil Pollution Act of 1990 (OPA) mandates extensive spill preparedness and planning in the form of Area Committees and the preparation of Area Contingency Plans. The U.S. Environmental Protection Agency (EPA) has assumed primary responsibility for implementing area planning on the nation's inland waters. The development of Area Contingency Plans for the inland zone requires the identification of sensitive areas as required by the Fish and Wildlife and Sensitive Environments Annex. The Sensitive Areas appendix to the Area Contingency Plan must include detailed information on environmental and human-use resources for evaluating risk, establishing protection priorities, planning mitigation strategies, and evaluating facility plans.

These new oil-spill planning requirements and the development of powerful yet low-cost Geographic Information Systems (GIS) software have stimulated efforts to automate information on sensitive areas. In EPA Region 5, computer-based information and mapping systems are being developed for oil-spill planning and response applications. EPA has cooperative agreements with two major basin commissions, the Great Lakes Commission (GLC) and the Upper Mississippi River Basin Association (UMRBA), to collect the environmental and human-use data. The Environmental Management Technical Center (EMTC) of the National Biological Service was contracted to generate the GIS databases and map products for the UMRBA effort in 1994.

In October 1993, EPA entered into an Interagency Agreement with the Hazardous Materials Response and Assessment Division of the National Oceanic and Atmospheric Administration (NOAA) to provide expert assistance to the EPA Region 5 Inland Area Planning Committee (IAPC) Work Group. NOAA has been developing sensitive area maps for areas under U.S. Coast Guard responsibility since 1980. Two tasks were identified:

Task 1: Provide technical assistance to the basin commissions, including on-site visits to make recommendations to improve data collection efforts.

Task 2: Develop guidelines for inland GIS databases and mapping, including formats for presentation of sensitive resource information, in association with EMTC.

This report documents the work conducted over the one-year period of 1 October 1993 to 30 September 1994.

2 A SUMMARY OF SENSITIVITY MAPPING APPROACHES

Over the last 15 years, immeasurable effort has been expended developing sensitivity mapping components of oil spill contingency plans. Scientists in North America, Europe, and elsewhere have published their mapping approaches, including Hayes et al. (1976), Lindstedt-Siva (1977), Michel et al. (1978), Owens (1979), Hayes et al. (1980), Getter et al. (1981), Bell (1981), Robilliard and Owens (1981), Adams et al. (1983), Klokk et al. (1983), Baca et al. (1985), Dossena et al. (1987), van Bernem et al. (1989), Harper et al. (1991), Ecological Consulting, Inc. (1992), Galagan et al. (1992), Michel and Dahlin (1993), and Percy (1993).

All but three of these approaches deal only with marine habitats and resources. Of the marine sensitivity mapping efforts used in the past, they can be divided into five basic approaches:

1. Environmental Sensitivity Index (ESI): Color-coded maps consisting of a shoreline ranking system, and sensitive biological and human-use resources indicated with symbols, species lists, and seasonality, but without ranking. Developed by NOAA and used in coastal areas of the U.S. since 1979 to generate over 2,300 map sheets (mostly on 1:24,000 topographic maps) in 45 atlases. Since 1989, maps and databases are developed using GIS technology.

2. Based on the U.S. Fish and Wildlife Service Wetlands classification system and data: Habitat sensitivity ranking system for saltwater wetlands by Adams et al. (1981). Prepared for the area covered by the Louisiana Offshore Oil Port plan in 1982, using overlays on 1:24,000 scale topographic maps.

3. Woodward-Clyde: Black and white maps, showing geomorphology of the shoreline and separate, subjective indices for oil persistence, biological sensitivity, and human-use resources. Tables list seasonal variability of indices. Used for

northern and central California in 1982 (1:24,000 scale topographic maps) and Chukchi Sea in 1985 (page-sized maps).

4 Marine Industry Group (MIRG): Black and white, paged-sized maps with symbols indicating sensitive biological resources, with facing page text that included a subjective ranking for sensitive locations on a relative scale of 1-3. Used to map sensitive areas throughout the Gulf of Mexico (from Florida to the Yucatan Peninsula in Mexico) in 1983.

5 British Columbia, Canada: A GIS database consisting of a hierarchical classification system used to summarize repetitive shore-zone types. Wave exposure/oil residence indices are used to define shoreline sensitivity. Complex models are used to rank biological, human-use, and special status area resources. Used to map parts of British Columbia in 1990-1993.

All of the currently used approaches for sensitivity mapping in marine settings incorporate a shoreline sensitivity ranking, identification of oil-sensitive biological and human-use resources, and some information on countermeasures.

There have been essentially three approaches to freshwater sensitivity mapping:

1 Canadian Great Lakes: Shoreline ranking scheme for Canadian Great Lakes was developed by Owens (1979), based on oil persistence predicted on marine models. The ranking scheme is shown in Table 1.

2 Environmental Sensitivity Index (ESI): Color-coded maps consisting of different habitat ranking systems for both Great Lake and riverine environments (extrapolated from marine models), and sensitive biological and human-use resources indicated with symbols showing seasonality. Used for all Great Lakes, St. Marys and St. Clair rivers, Columbia River, and Apalachicola River. The habitat ranking scheme for the Great

Table 1. Sensitivity of freshwater shoreline types to oil persistence (from Owens 1979) listed in order of decreasing sensitivity.

1.	Marshes
	Lagoons
2.	Sheltered rocky coasts
	Sheltered beaches
3.	Dunes
	Mud flats
4.	Pebble/cobble/boulder beaches
	Sand beaches
5.	Exposed rock or man-made beaches

Lakes shorelines is shown in Table 2. A very similar approach has been used by Environment Canada for recent mapping of the Canadian Great Lake shorelines (Table 3).

3 Based on the FWS Wetlands classification system: Proposed strategy for ranking of freshwater wetlands by Adams et al. (1981). Table 4 lists the five criteria for evaluation and the final priority rankings for the habitats present in the response area for the Louisiana Offshore Oil Port. Ratings for each criterion were based on numerical values, e.g., for habitat recovery, 1 = low, one year or less; 2 = medium, one to three years; and 3 = high, more than three years. Habitat ratings were derived from responses from biologists with oil-spill experience to a questionnaire, as well as from analogous saltwater habitats. Thus, some values in Table 4 include fractions because the responses were averaged. Baca et al. (1983) proposed a slight revision to this approach and included riverine wetlands, as

Table 2. NOAA's habitat ESI rankings for Great Lake shorelines, ranked in order of increasing sensitivity.

ESI No.	Habitat Type
1A	Exposed rocky cliffs
1B	Exposed vertical seawalls made of concrete, wood, or metal
2	Shelving bedrock shore
3	Unconsolidated sediment bluffs
4	Sand beaches
5	Mixed sand and gravel beaches
6A	Gravel beaches
6B	Riprap
7	Not present
8A	Sheltered rocky shores
8B	Sheltered solid man-made structures, such as bulk-heads
9A	Vegetated low banks
9B	Mud/sand flats
10A	Fringing marshes
10B	Extensive marshes

shown in Table 5. The criteria for the ratings were not described. In summary, the only sensitivity mapping approaches currently being used in freshwater settings are: 1) ESI shoreline rankings for lacustrine environments, developed as part of NOAA and Environment Canada projects in the Great Lakes, both ongoing since the mid-1980s. Environment Canada and NOAA have cooperated closely to ensure that the data structure and map representations are similar for the Great Lakes atlases; and 2) ESI shoreline rankings for large rivers, such as those used for the Apalachicola and Columbia rivers.

Table 3. Shoreline sensitivity rankings for the Canadian Great Lakes (Baker 1993).

ESI Ranking	Shoreline Type
Bedrock or Impermeable Shores	
1a.	Exposed Bedrock Bluff less than 1 m elevation
1b.	Exposed Bedrock Bluff 1-5 m elevation
1c.	Exposed Bedrock Bluff greater than 5 m elevation
2.	Retaining Wall/Harbour Structures/Breakwaters
3.	Shelving Bedrock
Unconsolidated Sediment Shores	
4.	Exposed Sediment Bluff
5a.	Sand Beach: Depositional
5b.	Sand Beach: Erosional or Transitory
6.	Sand Barrier with Lagoon
7a.	Pebble Beach
7b.	Pebble/Cobble Beach
7c.	Cobble Beach
8.	Riprap
9.	Boulder Beach
10.	Mixed Beach (% by sediment in DOE Database)
Vegetated Shores	
11.	Low Vegetated Bank (Grass or Trees)
12.	Delta Mud Flat
13a.	Fringing Wetland
13b.	Broad Wetland

Table 4. Summary of criteria evaluations for freshwater habitats by Adams et al. (1983), with 1 = least sensitive and 3 = most sensitive to oil effects. These criteria are then summed.

Freshwater Criteria	Freshwater Swamp	Freshwater Marsh	Freshwater Aquatic Bed	Fresh Open Water
Habitat recovery	3	1.7	2	1
Persistence of oil	3	2.3	1.3	1
Cleanup damage	3	3	2	1
Rarity	2	1	3	3
Important Species	2	3	2	3
Total	13	11.0	10.3	9
Priority Ranking	1	2	3	4

Table 5. Freshwater habitat ranking scheme proposed by Baca et al. (1983)[1,2].

Characteristics	Riverine Marsh[3]	Riverine Swamp[3]	Lacustrine Marsh	Lacustrine Swamp	Palustrine Marsh	Palustrine Swamp
Residence time of oil	1	1	3	3	3	3
Interior oiling	1	2	2	3	3	3
Length of time for recovery	1	1	2	3	2	3
Complexity of cleanup	1	1	2	3	2	3
Natural resource values	3	2	2	2	2	2
Specific effects						
Floating vegetation	1	1	2	2	2	3
Submerged veg.	1	1	3	3	2	3
Fisheries	3	2	3	2	1	1
Totals	12	11	19	21	17	21
Protection Priority Ranking	4	5	2	1	3	1

1 1 = low, 2 = medium, 3 = high

2 Based on the classification of Cowardin et al. (1979), riverine = wetlands, generally within a channel; lacustrine = generally standing water, with open water exceeding 30 percent of the system; palustrine = generally standing water dominated by vegetation.

3 Marsh here refers to predominantly herbaceous vegetation (grasses and sedges) and swamp to predominantly woody vegetation (shrubs and trees).

3 RECOMMENDATIONS TO IMPROVE DATA COLLECTION EFFORTS

Types of Data

The suggestions and discussions in this report regarding the data collection and structure were based on meetings with the commissions during 4-8 October 1993. Much of the data is already being collected by the commissions, so the sections on data collection may be redundant. However, they are included to preserve the continuity of the report and enable the reader to fully understand the scope of the project. After reviewing the forms currently being used, we made some suggestions to the format for data entry. Most of these changes were discussed with the project staff at each of the commissions during the visit, as well as being presented below.

There are six major classifications of resource data that are currently being collected for inclusion in the system: environmentally sensitive areas ("green spaces"); natural heritage data; archaeological and historic sites; water intakes; marinas and boat ramps; and Native American properties and hunting/fishing grounds. Potential spill sources are also included. We suggested that data on sensitive habitats and biological resources also be included.

Environmental Sensitive Areas

Environmental sensitive areas (green spaces) is a term used to identify all areas that have some sort of environmental protection status. Green spaces include all state and national parks, national monuments, wildlife refuges, conservation areas, preserves, reserves, and wild and scenic rivers. City and county parks are not usually included, except when these parks are of special significance, either in size, resources, or other factors. Some states have few state parks and rely on the city or county governments to establish parks. In these cases the local parks are included.

Information on green spaces can be collected from maps (e.g., county maps, topographic quadrangles) or state departments of parks and recreation or environmental control may have special maps (either digital or hard copy) of the state features. These features have to be entered as spatial data (digitize the outline of the feature) since they may cover a large area. The data table structure is shown in Appendix 1.

While many of the green spaces are fairly small, some can include multiple township/range boundaries or multiple counties. Having the location fields (e.g., township, range, section, county, latitude, longitude) may be appropriate for the small areas; however, this data structure becomes more difficult when dealing with large areas. The large areas could have one entry for each township/range or county in which they occupy space, or preferably they could have only one entry with the township/range information for the center of the feature, or the township/range that has the largest percentage of area entered in the appropriate fields. These data fields are only appropriate in a database-only format. With a digital mapping system, having a location in the database becomes less important because the spatial search will be conducted on the map and not the data.

The data structure being used by the commissions has a field for area of the feature, which becomes a redundant field once the data are entered into a GIS since the GIS program automatically computes the area of the feature. However, because the area is computed in map units (usually feet or meters), the area field could be kept to display area in units more meaningful to the user (acres or square miles). When the data have been digitized, the area field can be used as a check to determine the accuracy of digitization when the green space has a known area.

Originally, the Natural Heritage Program information was to be in the same data table as the green spaces. Our recommendation was to create a separate file for these data.

Presentation of the green spaces on the maps can be difficult because they range in size from less than one acre to thousands of acres covering several quadrangles. Using a solid fill to show green spaces would work well with small areas but would overwhelm the map on large areas. Showing just the borders of the green spaces might cause some of the areas to be lost on complicated maps. We recommended showing the border with an icon and name inside the borders on large areas and adjacent to the border on small areas for delineating green spaces on maps.

Natural Heritage Data

Natural Heritage data are compilations of the locations of species of plants and animals with special protection status. They are threatened, endangered, special concern, or potentially threatened or endangered at either the state or Federal level. Typically, the species included on sensitivity maps in the past were only the threatened and endangered species at state or Federal level. While there are many species of special concern, including all of them in the data can overwhelm the user and the important information may be lost in the flood of data. Using the threatened and endangered species as a selection criterion provides a focus on the most important species as well as including the species that have mandated protection at the state and Federal levels. Another restriction that should be used is to limit the species to those that may be affected by a spill in the water, or by the response and cleanup activities. Thus, only water-associated species of plants and animals, e.g., those present in the waterways, riparian habitat, floodplains, and wetland areas, should be included. Buffers could be selected around lakes, rivers, streams, and wetlands to limit the area of concern for collection and entry of threatened and endangered species distributions. For most cases, passerine birds and insects should not be included.

These restrictions on species to include are only guidelines. If state or Federal biologists feel very strongly about including another species, and a risk from a spill or cleanup action can be shown, the additional species should be included.

The endangered and threatened species have an unique characteristic that is not present in any of the other features included in the database. There is a temporal aspect to the location of many of the animals, which should be addressed in the data. The most appropriate strategy to include these data is a linked file that has the temporal information on the species. For plants, temporal data may not be necessary unless seasonal information on dieback, flowering, or other seasonal characteristic needs to be included. Appendix I shows the proposed data table structure for representing temporal information.

In many cases the guardians of the Natural Heritage data are unwilling to freely distribute the data to the public. They have many valid concerns about the use of the data and may need assurances that the information will not be misused. Below are some of the major concerns as well as some recommended ways to handle them.

- Information on the location of the species will become more available to the general public, with the potential of disturbance from increased visitation or vandalism. The exact location of the species does not have to be indicated on printed maps. Two strategies for data display include: 1) a polygon that includes, but is not limited to, the area of concern, can be shown on the map. The polygon should be drawn randomly about the area or point of concern, so that the user will be aware of a sensitive species in the area, but not be able to exactly locate the area of concern. An example is to draw an ellipsoid of approximately one mile in diameter around an eagle nest. The nest would not necessarily be in the center of the ellipsoid. 2) A special symbol could be used to indicate that a location-sensitive resource is present. Randomly placing the symbol within a set radius of the resource would alert the user to the fact that a sensitive resource is present but not identify the exact location. For example, a symbol representing eagles could be placed within one mile of the eagle nest. For this approach to work effectively during spills, the name and telephone number of the appropriate person or agency to contact about the resource should accompany the map and database. Spill responders need to know that there is a sensitive resource in the area so that the appropriate office/agency can be contacted and proper precautions taken.

2 How often will the information be updated? Based on past experience with updating, the physical updating process is not an issue. What takes the most time is determining what needs to be updated. If the Heritage people are able to provide the updated information (only the information that has changed), then conducting annual updates would be reasonable for the digital data. Distributing the updates in hard copy format will depend on the format the hard copy and how it was produced.

3 A request for all the data for the whole state is too broad. Depending on the data organization, such requests can involve a tremendous amount of work, which National Heritage Program staff are not willing or unable to undertake at the time. In many cases, if the request can be limited in spatial extent and by species, the response will be more favorably received. If, in fact, everything for the whole state is needed, then the appropriate approach may be to explain the extent of the project and request only part of the data (priority areas) initially with the understanding that more will be needed later. When requesting data from the National Heritage Program personnel, they need to be made aware of how the data are being used and educated on the importance of having the data available to spill responders. Otherwise, these resources will not be able to be protected in the event of a spill.

Archaeological and Historic Sites

Archaeological sites are a very sensitive historical resource, and therefore should be protected from potential damages resulting from an oil spill. The biggest concern is that the response and cleanup operations could cause physical damage to an archaeological or historic site. There is also the possibility that workers may find artifacts and remove them from the site during cleanup activities.

The format for the archaeological sites database is presented in Appendix 1. Since archaeological sites are usually point data or very small areas, entering values for latitude/longitude and township/range and section are needed to locate the site. However, the location of archaeological sites also need to be protected, so the exact location would not have to be given out or shown on publicly available maps. If the exact location is present in the database, it may be available to the general public under the Freedom of Information Act. The state historical preservation office may not be willing to release the data based on this possibility. The data may need to be restricted to just township/range and section. The latitude and longitude accuracy may have to be omitted. Most archaeological sites have some identifying number but not a name, so a field needs to be included in the data in which to enter the identifying number. The contact agency should be included in the database.

Water Intakes

Water intakes are one of the most important human-use features that are included in the data. Concerns are contamination of drinking water supplies, fouling of water-treatment plants, and shut-down of industrial facilities.

A point location should be marked for each water intake, even if one facility has several intakes. The information from the state should be confirmed and updated by the facility. This can usually be done by contacting the facility (by mail or phone call) to verify and update the data sheet. Expected turnaround for this type of request would be two to four weeks. The format for the data is shown in Appendix 1. In the source field of the data table, the facility would be listed as the source if they responded to the request for update, otherwise the agency that provided the initial information would be the source. If several agencies provided information and there was no response from the facility, then all the agencies that provided information would be listed as sources, with the primary agency listed first. The database should include the agency and telephone number to contact in the event of an emergency or to obtain more information.

Marinas and Boat Ramps

There are numerous sources for collecting information and locating marinas and boat ramps:

1. Collecting information on marinas is usually possible through a state agency that regulates the marinas. Boat ramps, however, may or may not be regulated, depending on the state. If there are regulations or licensing requirements by the state for boat ramps, then the agency that does the licensing could be contacted for information on the boat ramps.

2. The Chamber of Commerce may have maps showing the locations of marinas and recreationally used boat ramps, as well as some additional information on them.

3. State departments (e.g., fish and game and parks and recreation) may own many ramps, and thus would have information on these ramps.

4. USGS topographic maps and recreational guides will often have boat ramps marked on the map, but there is no additional information associated with them.

Appendix I shows the recommended data table format for boat ramps and marinas. Accurate latitude/longitude data should be obtained for the boat ramps and marinas, either from the source or generated when the location on a map is digitized. Boat ramps and marinas can be best represented by a dot at the location of the boat ramp or marina connected to a symbol by a leader line.

Tribal Indian Lands

These data, like the green spaces, are spatial in nature. The properties may include large tracts of land that cover several counties or may be as small as a city block. The areas are included because of the jurisdictional issues associated with tribal Indian lands. These lands are owned by the tribes, special status, and actions on these lands have to conform to the rules of the tribal owners. In many cases, contacting a representative for each tribe may be necessary. In addition to delimiting the actual land, the hunting and fishing areas of the various tribes need to be identified. There may be designated areas for subsistence hunting and fishing, or they may concentrate their efforts in certain areas. Although the general hunting and fishing areas are very large, the well-defined areas where most of the hunting and fishing takes place should be included.

The data collected for this information are similar to that collected for green spaces, as shown by the data format in Appendix 1. Native American properties and the hunting and fishing areas should be kept as two different layers and data sets. Contact names and phone numbers are necessary.

The map representation of the tribal lands can follow the same method as used for the green spaces. The hunting and fishing areas should be shown by a polygon with a hatched pattern. If the polygon will cover a large area of the map then the hunting and fishing area should be mentioned in a box indicating that it is present throughout the area ("Common Throughout" box).

Spill Source Facility Information

EPA provides this information based on their facility site surveys and data. The location of the facility should be verified, as oftentimes the reported latitude and longitude are incorrect or for a different location (such as the main office). Types and volumes of hazardous materials stored at the facility can be used to identify the relative risks of releases.

Habitat Identification

Habitat delineation and mapping were not included in the original description of the sensitive resources mapping project, however they are important features in spill response planning. The habitat determines the biological resources, the transport and fate of the oil, accessibility, protection priorities needed for cleanup, and many other response features. For coastal environments, a ranking scheme from one to ten has been develop based on the sensitivity of the habitat to oil. The ranking goes from vertical rocky cliffs (least sensitive) to extensive marshes (most sensitive).

There are numerous sources for mapping of sensitive habitats. EMTC has information for most of the Mississippi River and associated flood plain. About one third of the Mississippi River from Cairo, Illinois to the head of navigation has been classified. While the classification scheme is not the same as for sensitivity mapping, the information is available to convert it to an environmental sensitivity scale. Another source of data is the National Wetland Inventory (NWI). NWI data are available for most of the areas, but not all of it is in digital form.

The only fields needed in this database are for ESI rank/name and source. These data can not be set up as a database-only layer, they must be mapped, therefore location information in the database is not necessary.

Biological Resources

Currently the only biological resources included in the project are threatened and endangered species, thereby excluding most of the animals that may be impacted in the event of a spill. There are many species of birds, fish, shellfish, mammals, and reptiles which have commercial, recreational, or social importance that may be impacted by a spill. The information for these species should be collected as well as for the endangered or threatened species. Sources for the data would be state biologists, FWS biologists, and universities.

Also, there are often published reports and maps describing the biological resources of an area. These people and literature sources would be a starting point for collecting the data. This data collection and compilation effort is usually fairly intensive in terms of time and level of effort. The file structure and format is similar to the endangered species format in Appendix 1.

Data Formats

Since this project is being conducted by multiple groups, it is important to coordinate the data structure among the groups so that the delivered products can be integrated seamlessly. With the software currently available, the source format and structure are not very critical issues in delivering a consistent final product. If all groups have the same structure for the data, communications among the groups will be smoother and data will easily migrate back and forth between the groups. Appendix 1 shows the proposed data structures for the different layers of information.

Another issue in the data structure is export of the data to outside groups. With the ability to convert and export data, the information can be exported to an outside group in most any format or structure that would best meet their needs, or they could convert the data from the format or structure used in the project to meet their needs. The key feature is to document the structure, format, source, and other pertinent information about the data in a metadata file that is delivered with the data. With this metadata file the recipient can evaluate the data and modify it to meet his/her needs. NOAA is developing a standard metadata file for sensitivity mapping by the end of 1994 that meets Federal spatial data transfer standards, which should be considered for use in the inland mapping effort.

Hardware and Software

Computer Software

The mapping software being used for this project is Arc/Info. Arc/Info is supported on both the PC and workstation platforms. In determining which system is most appropriate, the use of the system needs to be evaluated. If the system is to be used primarily as data entry without much data processing or manipulation, a PC platform would be adequate. The PC platform is also considerably less expensive. Data are easily moved from a PC to a workstation; thus, data transferability is not an issue. It is recommended that an external database management system (DBMS) program be purchased to manage the data for the project. While Arc/Info comes with its own database program (Info), it is not very powerful. On the PC platform, a program such as dBase or Foxpro would be best. The PC version of Arc/Info stores its attribute data in dBase format so no translation is required to go between the DBMS and Arc/Info. On the workstation, a SQL-based DBMS (Oracle, Ingres, DB2, etc.) would be appropriate. Arc/Info allows links to most of these products, and the DBMS can manipulate the data more easily than Info. Many databases are structured around a one-to-one relationship. However, some biological resource data may be structured around a one-to-many relationship, requiring use of relational databases. If the file structure is dealing with relational files, the DBMS becomes almost essential, since Info does not work easily with relational files.

For accessing the maps and data from the final product, ArcView II is the best choice. It is relatively low cost, as well as easy to use. ArcView II will run on PCs, Macintoshes, and workstations. It has full access to all Arc/Info files. There is no conversion necessary between platforms. The user interface is intuitive and easy to use. The user can easily create special maps and views of the data.

Hardware

The hardware requirements depend on the level of work that the equipment is supposed to support. If extensive data (tabular and map) manipulation and extremely large data and map files are required, then a UNIX-based workstation may be the best choice. However, if the work will be mostly data entry or viewing and querying, then a PC-based platform would be adequate and possibly more cost effective.

A UNIX-based system should have at least the following configuration:

- 1.5 to 2 gigabytes of hard disk storage
- 24-32 megabytes of RAM
- 19" color monitor with 256 color and 1280x1024 resolution
- CD-ROM drive
- Tape backup with minimum of 2-gigabyte capacity

A PC-based system should have at least the following configuration:

- 486/66 DX2 Intel CPU
- 400-500 megabytes of hard disk storage
- 4-8 megabytes of RAM
- 17" color monitor with 256 color and 1024x768 resolution
- Tape backup with 250 megabyte capacity
- Either hardware disk caching controller or a software disk caching program (software is less expensive and works as well)

There is a large difference in the requirements of memory and disk storage and monitors between the PC and UNIX systems. The explanations are based in part on the software requirements, and in part on the underlying reason for using a UNIX workstation as opposed to a PC.

1 Hard disk - On a UNIX system, the operating system, Arc/Info, and DBMS program takes up approximately 700 megabytes of disk storage. In addition, both UNIX and all programs running on a UNIX system require swap space on the disk. To run Arc/Info, this swap space is about 100 megabytes. Therefore, total disk

usage is approximately 800 megabytes, with no data. On the PC platform, the operating system, Arc/Info, and DBMS take up about 30 megabytes of disk space. Since everything runs under DOS there is no need for swap space. The remainder of the disk is free for data. Also, the data sets that are used on the UNIX workstation are usually considerably larger than the data on a PC.

2 Random Access Memory - UNIX and Arc/Info on UNIX are much more complicated and robust systems than PC-based machines and as such require more RAM. Arc/Info requires a minimum of 16 megabytes of RAM to run on the UNIX system, but 24 megabytes of RAM improves the efficiency and speed at which it runs. On UNIX, the more RAM available, the faster the overall performance of Arc/Info. On the PC, Arc/Info runs under DOS and can only access 640 kilobytes of memory. The remaining memory on the system is not used by the software. The purpose of the additional memory is for use as a disk cache (if you have disk-caching software), or for use with Microsoft Windows. If Microsoft Windows 3.1 is installed, then the user can open up multiple DOS sessions and run multiple sessions of Arc/Info simultaneously.

3 Monitors - Arc/Info on the UNIX workstation and UNIX itself allow multiple windows to be open. The large screen and high resolution allow the user to have several large windows open on the screen simultaneously and be able to discern the necessary details in each window. On the PC, Arc/Info uses the entire screen for the graphics display and only supports 800x600 resolution. A monitor larger than 17 inches would be nice but the user would see little actual advantage to anything larger. The costs increase tremendously for monitors over 17 inches.

4 METHODS AND FORMATS FOR SENSITIVITY MAPPING PRODUCTS

Results of the February 1994 Workshop

At the February 1994 workshop in South Carolina, the working group met to decide on key elements of the mapping products. Using the digital data for the Twin Cities sub-area, both on-screen and hard-copy data displays were reviewed and discussed. The following recommendations or decisions were made:

1 The scale of data collection and digitization for sub-areas of special concern will be 1:24,000, based mostly on USGS 7.5-minute quadrangles. Sub-areas of special concern will include the river stretches that are commercially navigable and areas with large numbers of facilities (e.g., Detroit). For parts of the Mississippi River, EMTC will provide floodplain habitat data and the shoreline at a scale of 1:15,000.

2 The scale of data collection and digitization for other areas in Region 5 will be 1:100,000. The digital layers for the basemap will be compiled as follows:

Hydrography	TIGER files already at EPA
Roads	TIGER files already at EPA. TIGER files were selected over DLG files because they have been updated
Boundaries	DLG files already ordered by EPA
Railroads/Pipelines	DLG files already ordered by EPA. It is realized that only the features shown on the maps will be included
Annotation	DLG files will have to be purchased

The 1:100,000 USGS topographic map will be the hardcopy basemap for data compilation. It was estimated that 30-40 of these maps will cover each state. They are at the same scale as the digital base map and do not have boundaries along major rivers, as do many of the county maps.

3 EMTC is to compile these files and generate the 1:100,000 basemap files for Region 5. They will generate hardcopy maps for each of the 1:100,000 USGS maps for the entire area.

4 For the pilot sub-areas, sources for information on wetlands will be identified and evaluated for accuracy and currency. Criteria for which wetlands to include will be determined during the pilot studies.

5 Sensitive biological and human-use resource data to be collected for the pilot areas will include information on birds (waterfowl concentration areas, nesting sites for species other than threatened and endangered), fish (important spawning and nursery areas, known concentration areas), and other resources as identified.

6 NOAA is to provide digital files for the icons for the biological and human-use resources. These symbols will be used on the pilot maps and evaluated for wide-scale use.

Review of Draft Sensitivity Maps

Based on the map format agreed to during the February 1994 workshop, EMTC developed two draft sensitivity maps for the La Crescent quadrangle along the Mississippi River for consideration by the Inland Area Planning Committee Working Group in April. NOAA was asked to review the maps, and the following comments on the draft maps were provided.

1 Maximum space should be made available for the map, within the 11 x 17 inch format, so that the maps are at the largest scale possible. Thus, the map title across the top should be removed. The map name and number should be placed in the lower right corner. A map numbering scheme needs to be developed.

2 The ratio scale (e.g., 1:35,000) should be included in the legend.

3 The legend should be organized by data type. We follow this convention:

Habitats

Sensitive Biological Resources

Human-Use Resources

Response Information

4 The scanned base map was too light. We will send several versions of the same scanned base map, at different scales of darkness and degrees of intensity of scanning.

5 The use of a solid green color for all land cover classifications should be reconsidered. It generalizes too much and even misleads, especially with the natural-looking green color in urbanized areas. The following color scheme is suggested: water (light blue), permanently flooded wetlands (blue green), seasonally flooded wetlands (light green), agriculture/forest upland (tan), and urban (gray). The strategy is that permanently flooded wetlands would have a mechanism for direct contamination by floating oil slicks during all but very low water, whereas seasonally flooded wetlands would only be at risk during flood stages. Also, transparent colors should be tested and compared with opaque colors, to see if being able to see the underlying scanned map information is useful. By using lighter colors, the hatch patterns, symbols, and other features will be more visible.

6 The determination of shoreline habitats should be documented. It appears that all urban areas were assigned

"riprap/revetments" which cannot always be inferred. Also, "vegetated banks" appear to have been inferred from forested areas, again, which is not always the case. Since the data do not support a shoreline classification, we recommend that the different habitats being mapped be grouped as above, if possible.

7 If a linear shoreline classification is used, the colors should match those used on traditional ESI maps and reflect the relative sensitivity. As it is on the draft maps, the orange riprap color is too close in color to the red roads.

8 The river mile numbers are too small to read. Also, the highway symbols are too small.

9 Only the truly sensitive biological resource information should be shown with a fill pattern. On the draft maps, the refuges, state forests, and parks are shown in different hatching patterns. Large parts of these managed areas are not very sensitive to oil spills. Instead, the fill or hatch patterns should be used for those areas which are truly sensitive, such as fish-spawning areas, waterfowl concentration areas, etc. The boundaries of the managed areas should be outlined, they should be named, and an icon/number placed within or adjacent to them to flag their presence.

10 The truly sensitive areas should be identified using color-coded fill patterns, i.e., blue for fish, green for birds, etc. if possible. With large areas of color fill for the land cover, it may not be possible to use color hatching. We use black for areas that include more than one major element (i.e., birds and fish) and also include icons for all major element present (e.g., on the draft map the sensitive area no. 101 would have both a waterfowl and a fish icon, so the user could readily see that both groups of organisms were present). As shown on the draft map, the user would assume that only waterfowl were present. Also, the fill pattern of the circle is too dark, making the icon difficult to see.

11 Eventually, some sensitive resources need to be identified at the species level, e.g., bald eagle nesting sites. It is not necessary or of value to generate a long list of waterfowl or fish species for each sensitive area. However, where a specific species is of concern, species-level information will be needed.

12 Seasonality information on the sensitive areas is lacking and very much needed. It could be added to the attribute information on the back of the map.

13 The legend on the front of the map lists "Aquatic Habitat" with the green circle and the waterfowl icon and "Sensitive Biological Areas" as a hatch pattern, yet the back legend calls these "Bio-sensitive areas," which is confusing. "Sensitive Biological Areas" should be a major heading, with the types of sensitive biota listed below with their appropriate icons (e.g., raptors, waterfowl, fish, reptiles, etc.).

14 Unique identifiers are needed to reference the data shown on the maps to tabular data on the back of the map. We prefer to keep the numbers limited to three digits (1-999) because of the space requirements, especially on the river maps where so much information is packed close together. It may be necessary to divide the river into sub-regions, but making sure that the numbering system allows plotting out data for various scales of coverage.

15 The lists printed on the back should always be in numerical order. Thus, the boat access points should start with 1. Numbering intervals should be assigned to each major type of information.

16 The biological information should be listed first on the back of the map, then the human-use resources.

17 The legends should not be map specific, as it appears on the draft map. There should be one all-inclusive legend, so that there is no confusion about what information is shown.

Otherwise, there is the potential that the user might assume that waterfowl were not included on the maps, rather than that they are not present on a specific map.

18 The list of spill containment equipment changes so frequently that we question the utility of listing this detailed information in the legend. The name, location, and phone are more appropriate for a hardcopy atlas.

19 The solid circle for the potential spill source tends to dominate the maps. A small triangle without a circle is suggested, so to separate it from the other resource information.

20 The numbers for each icon appeared to be too large relative to the icon size.

21 The icons on the front legend should not be shown in a box; rather they should be listed just as they are shown on the maps.

22 The habitat colors should be shown as a solid fill in a box rather than the "Z," to make it easier to see the color.

5 GUIDELINES FOR DELINEATION AND RANKING OF SENSITIVE AREAS

Introduction

The primary goal of this report is to propose an approach for sensitivity mapping for EPA Region 5 that both meets the OPA planning mandates and provides wider access to spill planning and response information. EPA Region 5 covers a complex and diverse range of terrestrial habitats. No one strategy can address all of the requirements for identifying sensitive resources, setting protection priorities, and supporting decision-making during spill response. Rather, a combination of strategies is needed that includes: 1) shoreline-habitat mapping and ranking, for use in lacustrine and (large) riverine settings; and 2) a watershed approach for small rivers and streams, and terrestrial areas.

Shoreline-Habitat Ranking Approach

Table 6 lists the proposed ESI rankings for use in sensitivity mapping in the lacustrine and large river settings. This shoreline-habitat ranking approach has a strong scientific basis in estuarine and lacustrine settings, and it has been proven to be effective as a planning and response tool for nearly fifteen years. The habitat-ranking scheme has been widely incorporated into spill decision-making aids, including two manuals published in 1994 on cleanup options in freshwater environments (NOAA and API 1994) and mechanical protection guidelines (NOAA and USCG 1994). It is very important to have consistent habitat designations throughout the planning process and response operations.

Table 6. Proposed habitat ESI ranking for habitats in EPA Region 5.

ESI NO.	LACUSTRINE	RIVERINE (large rivers)
1A	Exposed rocky cliffs	Exposed rocky banks
1B	Exposed, hard man-made structures	Vertical, solid revetments
2	Shelving bedrock shores	Rocky shoals; bedrock ledges
3	Eroding scarps in unconsolidated sediments	Exposed, eroding banks in unconsolidated sediments
4	Sand beaches	Sandy bars and gently sloping banks
5	Mixed sand and gravel beaches	Mixed sand and gravel bars and gently sloping banks
6A	Gravel beaches	Gravel bars and gently sloping banks
6B	Riprap structures	Riprap structures
7	Exposed flats	Not present
8A	Sheltered scarps in bedrock	Vegetated, steeply sloping bluffs
8B	Sheltered man-made structures	Sheltered man-made structures
9A	Sheltered vegetated low banks	Vegetated low banks
9B	Sheltered sand/mud flats	Muddy substrates (unvegetated)
10A		
10B		
10C	Freshwater marshes	Freshwater marshes
10D	Freshwater swamps	Freshwater swamps

The lacustrine habitat rankings reflect the environments present on lakes. This approach would be applicable to large lakes only. The cut-off in lake size would occur where the fetch (distance over which the wind blows to generate waves) is long enough, and thus the wind-generated waves large enough, to form beaches along the shoreline.

Lakes with naturally formed beaches would be large enough for consideration of shoreline mapping using the ESI. For lakes without these wave-built beaches, the shoreline is often composed of low, vegetated banks and wetlands. In these smaller lakes, bogs, ponds, etc., only the wetlands would be mapped and ranked as the most sensitive habitat. No relative ranking of freshwater wetlands is proposed, mainly because there is inadequate information on which to assign rankings. Even the ranking of freshwater wetlands by Adams et al. (1983), shown in Table 4, had very little spread in the values among wetland types. However, it is important to differentiate between freshwater marshes (composed of herbaceous vegetation such as grasses and sedges) and swamps (composed of woody vegetation such as shrubs and trees).

EMTC is currently generating detailed wetland maps and spatial databases for large parts of the upper Mississippi River, using new aerial photography taken in 1993 and the NWI wetland classifications. Where these data are available, it is possible to include a limited number of wetland classes. The Fish and Wildlife Service is digitizing the wetland units as delineated on the existing NWI maps, which are based on aerial photography taken during the 1980s. These data are being digitized to meet high map-accuracy standards, but on a quadrangle basis. Since no effort is made to edge-match between quadrangles, much effort will be required to generate contiguous coverages. Only where other groups have edited NWI data should it be considered for inclusion on sensitivity maps.

Table 6 includes a proposed new ranking scheme for large rivers. Large rivers can be mapped using a shoreline-habitat approach because they have distinct shorelines or banks that vary significantly in sensitivity. Large rivers can be divided into individual components that can be classified and ranked in a meaningful manner. A sensitivity ranking for rivers has been developed based on an understanding of the geomorphology and physical processes active in large rivers.

To demonstrate the riverine ESI, a model has been constructed of a typical, medium-sized coastal plain river. Figure 1 shows the geomorphic components of this meandering river system, and the ESI maps for the model is given in Figure 2. The associated biological and human-use resources for the model are shown as a separate layer (for clarity) in Figure 3.

The model illustrated in Figures 1-3 demonstrate the relative ease with which the ESI mapping system can be applied to rivers. The mapping encompasses those areas covered by water in a normal annual cycle. Figure 4 shows water levels to be expected during ten-year and hundred-year floods. We do not recommend making separate maps for the different flood levels because oil spilled during the flood would: 1) be carried on through the system; 2) be deposited on high ground (and hence essentially be an upland spill when the flood subsides); and 3) eventually end up in the main channel or floodplain wetlands which are mapped. However, specific flood levels should be included in the database and shown on the maps because potential flooding of facilities is an important component of the risk assessment. It may be possible to develop digital elevation models to determine these risks.

Whereas only one type of river system (meandering) is presented for discussion here, our experience indicates that a similar mapping program could be developed for all large and medium-sized rivers in the U.S. For small streams, we propose a different approach, the watershed approach, for mapping environmental sensitivity.

Watershed Approach for Habitat Sensitivity

As one progresses landward up major river courses, the streams and associated ponds and wetlands eventually become so narrow and shallow that even small spills would potentially contaminate the whole system. The size is such that the contents of a typical tank truck or rail car (20,000 gallons) would affect the waterbody, from bank to bank, and the entire water column. Therefore, from that point on upstream, it is not useful to classify the small individual

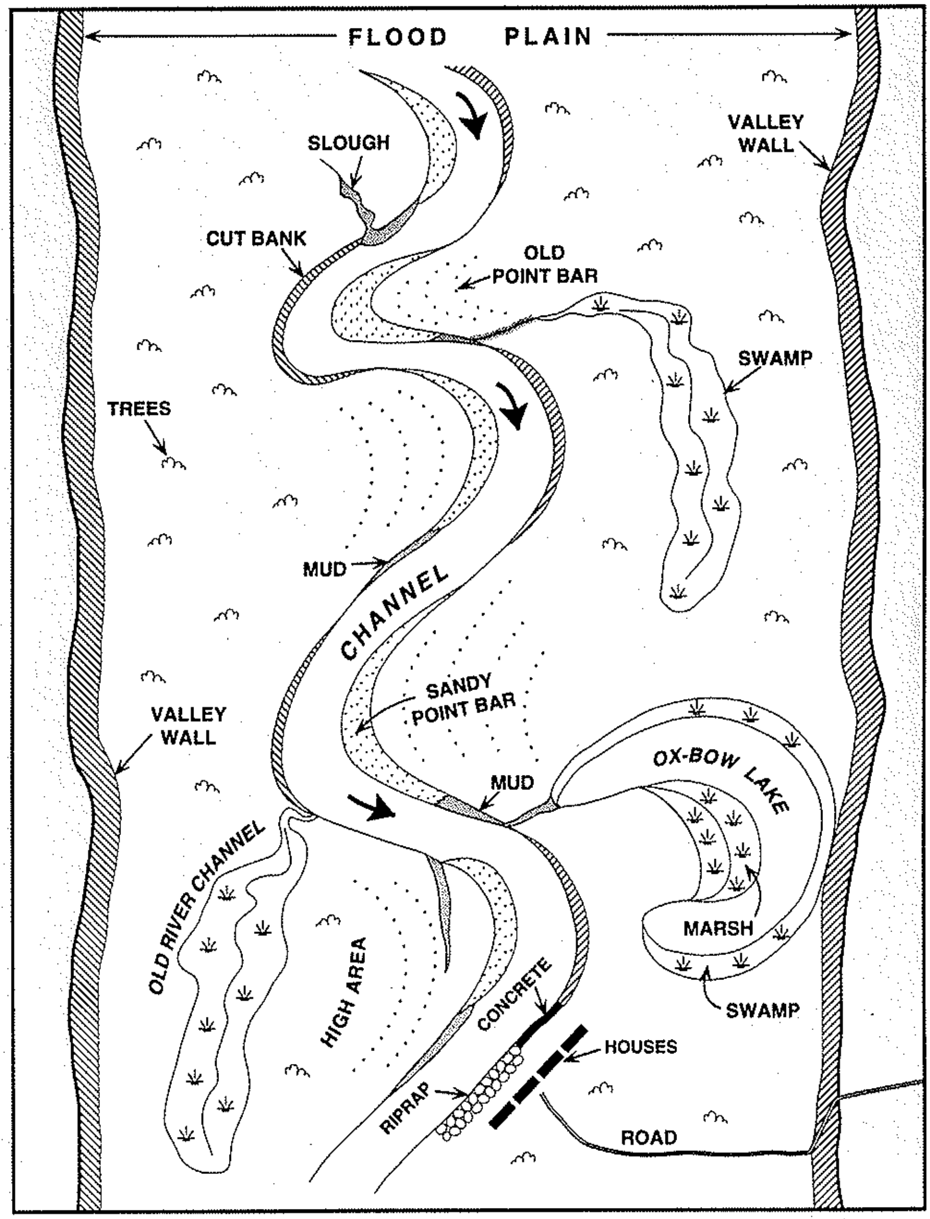

Figure 1. *Geomorphic components of a model for a medium-sized, meandering river.*

components of the stream system with regard to habitat sensitivity. Rather, the sensitivity of the system as a whole should be considered.

A logical way to approach planning for spill response in these smaller stream systems is to consider the <u>entire watershed</u> upstream of the

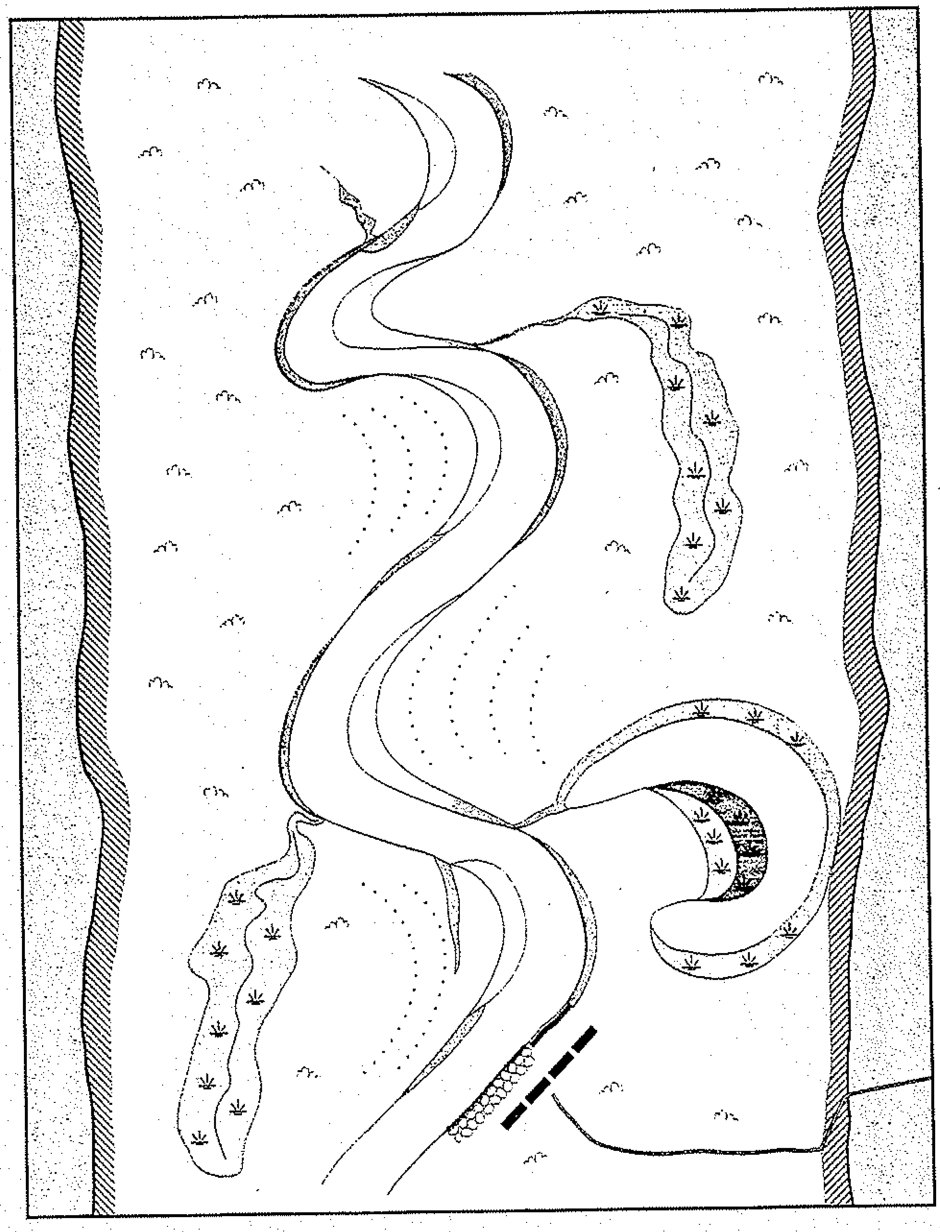

Figure 2. Application of the shoreline-habitat approach for ESI mapping of rivers. The key for the shoreline ranking is shown on the following page.

point on the main stream where the standard riverine ESI mapping approach is terminated. We believe considering the watershed as a unit is justified in the context of this report because the drainage network of the watershed is the avenue by which pollutants will be

ESI RANKINGS
RIVERINE HABITATS

- 1A. Exposed rocky banks; 1B. Vertical, solid revetments
- 2. Rocky shoals; bedrock ledges
- 3. Exposed, eroding banks in unconsolidated sediments
- 4. Sandy bars and gently sloping banks
- 5. Mixed sand and gravel bars and gently sloping banks
- 6A. Gravel bars and gently sloping banks
- 6B. Riprap structures
- 7. Exposed flats (not present)
- 8A. Vegetated, steeply sloping bluffs
- 8B. Sheltered man-made structures
- 9A. Vegetated low banks
- 9B. Muddy substrates (unvegetated)
- 10A. Freshwater marshes
- 10B. Freshwater swamps

dispersed. Consequently, the effectiveness of response to a spill upstream of any given point along the stream will determine the likelihood of that location being polluted.

The exact location of the point along the main stream where standard riverine ESI mapping is terminated and the watershed approach is initiated cannot be determined at this time. More detailed analysis of stream characteristics and potential criteria will be needed. However, it is probable that the ratio of stream gradient (S) to stream discharge (Q; usually measured in cubic feet/second) will be valuable parameters, at least in part, to make this determination. The ratio S/Q has long been used as a measure of river morphology (e.g., Gilbert 1877), with the value generally decreasing in a downstream direction (Carlston 1968). Other factors, such as climate and steadiness of discharge, should also be

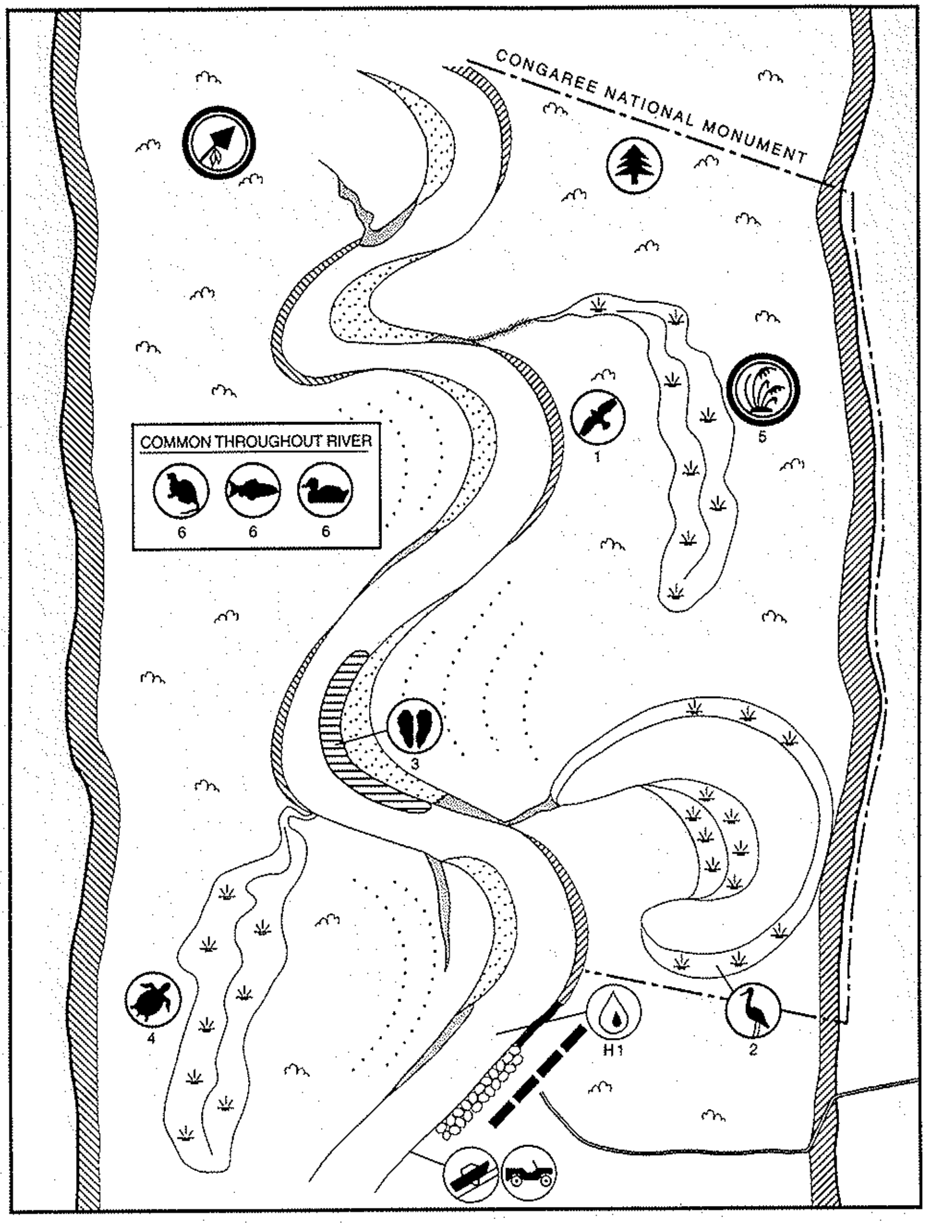

Figure 3. Example map of biological and human-use resources for rivers. The data for the numbered polygons and points are on the facing page.

considered. Further discussion of these interrelationships is beyond the scope of this report.

Another important concept in stream morphology, or configuration, is that most streams are subdivided into clear-cut segments, or <u>reaches</u>, that have very distinct and uniform characteristics within that stretch of the stream. A reach of the stream usually begins and

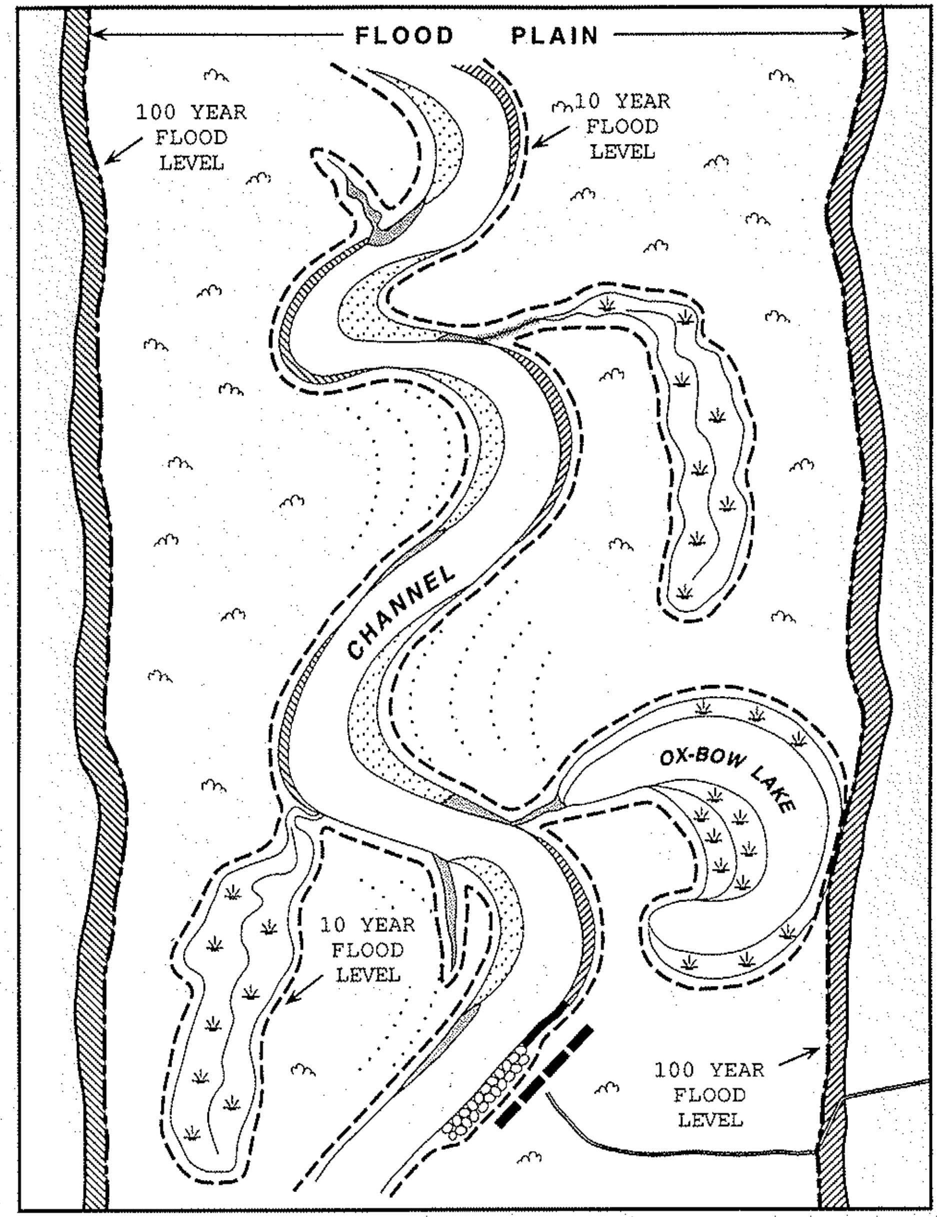

Figure 4. Example flood levels for the 10- and 100-year floods. Such flood levels should be included in the database.

ends at some geomorphic threshold, defined by Schumm (1973) as a threshold that is developed within the geomorphic system by a change within the system itself through time (e.g., continuous downcutting of the stream bed until a resistant rock layer is encountered). Geomorphic thresholds are most commonly expressed in smaller stream systems by relatively abrupt changes in gradient, that are usually brought about by changes in the bedrock geology of the stream bed. Therefore, most small streams are composed of a series of reaches that exhibit marked differences in gradient, which results in striking changes in the morphology of the stream from reach to reach (e.g., changing from straight, to braided, to meandering channels, with associated changes in sediment type). These marked differences in morphology and sediments among the different reaches of the stream have a strong influence on the biological makeup of the various types of reaches in the stream. Furthermore, different techniques of spill response will be required for the different reaches of the stream because of variances in potential residence time, long-term impacts, mixing of oil in the water column, and other behavioral patterns of the pollutant.

A model of the application of the watershed approach to habitat sensitivity mapping is given in Figure 5. In this model, the riverine ESI mapping is terminated just at the downstream edge of the watershed, and from there upstream, the watershed method is employed, emphasizing the reaches in the streams. The model also contains a fairly large man-made lake, which could be mapped using the lacustrine ESI. In the model, the streams within the watershed have three characteristic reach types: Class A, for which $S/Q = x$; Class B, for which $S/Q = x - a$; and Class C, for which $S/Q = x + a$, with "a" representing an increase or decrease in the ratio relative to the value of the Class A reach. Values for the ratios have not been calculated for the model, but values of S and Q can be obtained or calculated for most streams in the U.S.

The reaches classified as A in the model (Figure 5) have a moderate gradient, relatively straight channels, brisk currents, intermittent rapids, and sand and gravel bars. A moderately wide zone of riparian vegetation occurs along the stream margins in these reaches. Spilled oil in these reaches would have a relatively short residence time, and there would be few workable sites within which to contain and collect the oil. Because of the presence of rapids in places, there would be significant mixing of the oil into the water column.

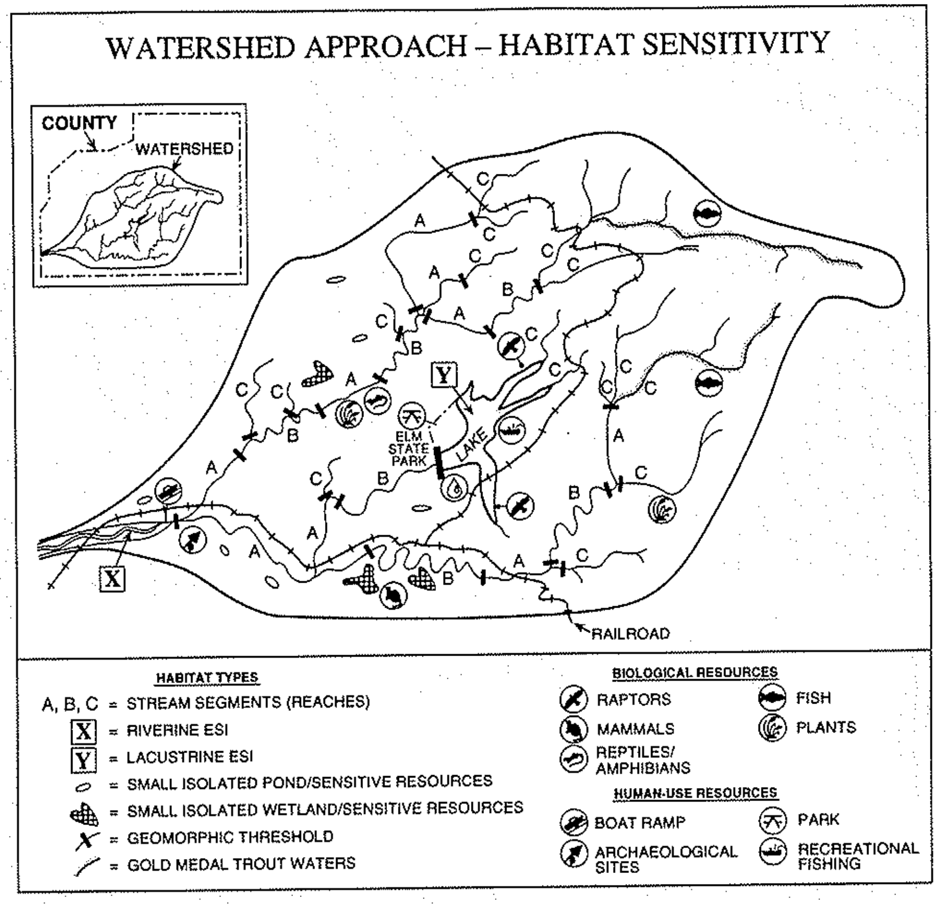

Figure 5. Model of the application of the watershed approach for sensitivity mapping of small rivers and streams.

Reaches classified as B have a relatively low gradient, meandering channels, moderate currents, and sandy bars on the inside of the meander bends. Wide zones of associated riparian vegetation are present away from the cutbanks of the meanders. Spilled oil in these reaches would have intermediate residence time (compared to the other types of reaches). There would be numerous collection sites where deflection booms could be used to trap the oil for eventual collection (e.g., against clay banks cut by the meandering channel), and mixing of the oil into the water column would be limited in comparison with the other reach types.

Reaches classified as C have a very steep gradient, straight to braided channels, very strong currents, and coarse gravel in the stream bed and along the banks. Rapids are numerous. Zones of riparian vegetation would be extremely narrow. Spilled oil in these reaches would have a short residence time, but it would be mixed throughout the water column because of the abundance of rapids. There would be no desirable sites to contain and collect the oil. These reaches would typically have the purest water quality, coolest temperatures, and abundant sensitive aquatic insect life.

As shown in Figure 5, the classification of a stream reach does not always progress from C to A. Streams switch from one class to another, depending on various factors such as the slope and local geology. A low-gradient, meandering stream may become steep and full of rapids as it cuts through a gorge, then return to a meandering stream in the next valley.

In the watershed approach, other sensitive small habitats, such as isolated wetlands and small ponds, are shown. Data on the distribution and seasonality of sensitive biological and human-use resources present in the watershed would be collected and displayed using the same data structure and symbology used on the shoreline-habitat sensitivity maps. The scale of data resolution and entry will have to be further evaluated. With information on the location of facilities, and analysis of the spill volumes and transport times, the risk of impacts to sensitive resources could be determined, both visually and through spatial analysis of the resources present in different watersheds.

Sensitive Biological Resources

There are numerous animal and plant species that are potentially at risk from oil spills. Table 7 lists the major groups to be included on inland sensitivity maps. There are seven major biological categories, and each category is further divided into groups of species or sub-categories with similar ecological behavior relative to oil spills. Each of these sub-category groups is composed of individual species that have similar oil-spill sensitivities.

Table 7. Sensitive biological resources for inland sensitivity mapping.

Category	Sub-Category	Priority Sensitive Resources
Benthic Habitats	Submerged aquatic vegetation	Includes all types of grass beds
	Surficial gravel deposits	Locations where deep oil penetration from surface spills is likely
Terrestrial Mammals	Water-associated species (e.g., otter, mink, muskrat)	Concentration areas
	Endangered species	Important habitats
Birds	Diving birds	Rookeries; Forage/wintering areas
	Waterfowl	Nesting/wintering/migratory areas
	Shorebirds	Nesting beaches; Important migration stopover areas
	Wading birds	Rookeries; Important forage areas
	Gulls/Terns	Nesting sites
	Raptors	Nest sites; Important forage areas
	Endangered species	Important habitats
Fish	Anadromous fish	Spawning stretches of streams
	Shoreline spawners	Spawning beaches/areas
	All fish species	Nursery areas; Special concentrations
	Endangered fish species	Important habitats
Shellfish	Mussels	Endangered freshwater mussel beds
Reptiles/ Amphibians	Endangered species	Important habitats
Plants	Endangered species	Important habitats

The types of biological resource areas which should be included are annotated in Table 7. Many species are wide-ranging; they can be present over a very large area at any time. Maps or data indicating the entire area of occurrence of fish species, for example, can cover very large areas and thus do not help responders in assessing resources at risk and setting protection priorities. However, natural resources are most at risk from oil spills when:

- Large numbers of individuals are concentrated in a relatively small area, such as bays where rafts of waterfowl concentrate during migration and overwintering.
- They come ashore for birthing, resting, or molting.
- Early life stages are present in somewhat restricted areas, such as spawning beds for anadromous fish and bird nesting colonies.
- Areas important to specific life stages or migration patterns, such as foraging or overwintering sites, are impacted by oil.
- Specific areas are known to be vital sources for propagation.
- The species are threatened or endangered.
- A significant percentage of the population is likely to be exposed to oil.

Sensitivity maps should show where these most sensitive species, life stages, and areas are located, not the entire area over which the species are known to occur. Several types of distributions are shown. Point locations are used for sites of very small areal extent, such as bird nesting colonies. Lines are used to show sites along a shoreline or stream which is used for a specific activity, such as the length of a stream used for spawning by anadromous fish. Biological distributions which are spread over an area, such as nursery areas for fish, preferred habitat for river otters, or high concentration waterfowl overwintering areas, are indicated by polygons with patterns. Figures 3 and 5 show example presentation formats.

Associated data for each element which should be included, at the species level, are:

- Lifestage present, for each month of the year;
- Concentration present;
- Status, whether endangered or threatened, on state or federal lists;
- Start/end dates for specific breeding activities; and
- Expert contacts for the resource.

These data allow identification of the most sensitive periods for each species and determination of protection priorities on a seasonal basis. For each species or species group, detailed information is provided on the life stage present by month of year.

For fish, emphasis is placed on important spawning and rearing areas in shallow-water environments, where sensitive life stages are concentrated and at risk of exposure to high levels of oil in the water column. Nursery areas for larval and juvenile fish, particularly for species of commercial or recreational importance, are delineated. Life-stage information includes larvae and eggs, and breeding activity includes months when adult spawning and outmigration of fry occur.

Threatened and endangered species should be indicated with a special flag in the data tables to indicate their management status. For some endangered species of plants and animals, there is considerable concern about showing the location on public maps. Publication of these locations might result in increased visitation and thus disturbance or vandalism. For these location-sensitive resources, the exact location is not shown on the maps. Instead, the presence of the resource is indicated using a symbol located within a set distance from the resource, but in a random direction. The symbol is flagged so that the user knows that the exact location is not shown, and the appropriate contact is included in the data tables.

The data tables include lists of key contacts or resource managers for special species of concern, that is, someone who could be contacted to provide current species status or special protection requirements. The contacts/managers entry could be unique for each resource location, or there could be general, resource-wide contacts, such as the State Heritage Program for all endangered plant locations.

Human-Use Resources

Table 8 lists the human-use resources that are at risk from oil spills. Human-use resources can be divided into four major components:

- High-use recreational use and shoreline access areas

Table 8. Sensitive human-use resources for inland sensitivity mapping.

Category	Sub-Category	Priority Sensitive Resources
Recreation	Beaches	High-use recreational beaches
	Marinas; Boat ramps	Use and access points
	Boating; Fishing; Swimming; Diving areas	Major or designated water recreation areas
	State/County parks	
Management Areas	Federally protected areas	National Marine Sanctuaries and Estuarine Research Reserves; National Wildlife Refuges/Parks; Wild and Scenic Rivers; Wilderness Areas, etc.
	State and local protected areas	Preserves; Reserves; Heritage Trust lands; Wildlife Management Areas, etc.
Resource Extraction	Subsistence	Designated subsistence harvest sites
	Commercial fisheries	Concentration/high use areas
	Surface water intakes	Use (drinking; industrial; power; irrigation); Volume; Population served
	Ground water supplies	Well locations (depth to water table; aquifer type and media; use; population served); Wellhead Protection Areas
	Aquaculture facilities	Fish; Bivalves; Plants
	Log storage areas	
Cultural	Archaeological sites	Known sites; type; contacts
	Historical sites	Known sites; type; contacts
	Native lands	Reservations/Culturally important sites

- Officially designated natural resource management areas
- Resource extraction sites
- Water-associated archaeological, historical, and cultural sites

Recreational areas shown on sensitivity maps should include high-use recreational beaches and sport-fishing, boating, and diving areas. Boat ramps and marinas are shown, both as recreational sites and access points for response activities. Name/phone contacts for marinas and parks are needed for notification and collection of information on site suitability for water access and construction details needed for operations support.

Officially designated natural resource management areas include national parks and marine sanctuaries, national wildlife refuges, wildlife management areas, preserves and reserves set aside by various agencies and organizations, and other ecological sites that have special resource management status. Contact and phone number for the management area are included for notification and inquiry as to current conditions (e.g., number and species of waterfowl actually present or expected in the near future).

Water resource protection includes 1) surface water intakes and 2) groundwater recharge zones and well fields. Contact information for water intakes (including exact location, depth of intake, use, volume, presence of alternative sources) is critical. It may be necessary to consider higher cleanup standards or more intrusive removal actions if oil spills contaminate sediments overlying recharge zones or shallow wells. Groundwater protection may be of particular concern for spills of light products in rivers where wells are located in the floodplain and are hydraulically connected to the river.

Where appropriate, log storage sites and benthic mining leases are included so that appropriate protection and cleanup strategies can be developed. Each has a unique problem that can significantly complicate oil removal activities. For example, special care and notifications may be needed during cleanup activities involving sediment removal in the vicinity of mining leases. The boundary, owner/user contact, and type of activity is provided for each site.

High-value commercial fishing areas are a very critical component. Many times the concern is to minimize impacts to the catch and fishing equipment as gear is pulled from the water through surface slicks. For each area, the boundary, species being utilized, time of use, and data on catch for that area are included. Non-commercial seafood harvest areas, including subsistence use areas, identify sites where monitoring of seafood quality may be needed to protect local populations in the event of a spill.

The most sensitive type of archaeological sites are those that are actually located in floodplains or along river banks, where they have been exposed by erosion. Also, sites located very close to the bank where they may be crossed by response or cleanup crews are included. The type and status (e.g., on National Register) of each site is described. If there are multiple sites in a general area, then the area and number of sites should be indicated. Site-specific information for some highly sensitive or important archaeological resources may need to be restricted in distribution to prevent unnecessary site visits by the curious, as well as destruction by vandals. For these location-sensitive resources, the exact location is not shown on the maps. Instead, the presence of the site is indicated using a symbol located within a set distance from the site, but in a random direction. The symbol is flagged so that the user knows that the exact location is not shown, and the appropriate contact is included in the data tables. Figures 3 and 5 show example formats for map presentation.

6 STANDARDS FOR MAP SYMBOLIZATION

Habitat Sensitivity Ranking

Use of color in indicating a shoreline habitat ranking and sensitivity is mandatory. It is not possible to differentiate among the ten or more classes with patterns alone. In fact, extensive research has gone into the selection of a logical color scheme that indicates increasing habitat sensitivity and can be differentiated by the typical user. The standard color scheme used on ESI maps displays shoreline habitat sensitivity from least sensitive to most sensitive (Table 9).

Table 9. Standardized color scheme for ESI habitat rankings.

ESI Rank	Color	CMYK Percentages
1	Dark Purple	56/94/0/13
2	Light Purple	38/31/0/0
3	Dark Blue	88/31/0/0
4	Light Cyan	25/0/0/0
5	Cyan	56/0/0/0
6A	Forest Green	100/0/88/0
6B	Green	44/0/100/0
7	Olive	0/0/94/25
8A	Yellow	0/0/100/0
8B	Yellow-Orange	0/34/28/0
9	Orange	0/25/88/0
10A	Red	0/75/81/0
10B	Light Magenta	0/50/0/0
10C	Dark Red	0/81/56/13
10D	Brown	0/56/69/25

Although many more colors are possible, these colors have been tested and optimized to provide the best contrast when used as a narrow band of color and for color photocopy reproduction. The emphasis was on selecting different colors for the more sensitive shoreline types (e.g., 8A and 8B), whereas the same color pattern is used when there are sub-classifications of the less sensitive shorelines (e.g., 1A and 1B). These colors have been standardized on all NOAA sensitivity maps.

Line patterns should never be used to represent the habitats, since patterns become very distorted when the line goes around tight curves. Colored lines displayed on the shoreline are centered on the actual shoreline. If the colored line is offset from the true shoreline, there will be gaps or overlaps at the ends of the segments if they end at a sharp point of land or at the head of a cove.

Some of the habitat classes, such as wetlands, are best represented by polygons. These polygons are drawn and have a solid fill pattern of the appropriate color. The bounding edges of the polygon do not have the line type or color of that particular habitat rank. The line is represented either as a thin black line or not drawn.

Symbolization for Biological Resources

Most biological resources are best represented by polygons, although bird nesting sites are represented as points, and fish streams are usually represented as lines. The points, polygons, and lines representing the different animal groups are color-coded. Polygons for each of the animal groups are colored according to the following scheme:

Fish — Blue

Birds — Green

Reptiles/Amphibians — Red

Shellfish — Orange

Mammals — Brown

Plants — Purple

Polygonal data can be represented in several ways depending on the intended use of the information and the output device. The options are fill patterns, symbols in or on the boundary of the polygon, or mnemonic codes in or on the boundary of the polygon, or symbols shown without the bounding polygon. Traditional ESI maps relied heavily upon the use of symbols to aid in the identification of species groups present, and this approach has been widely accepted. The first sets of GIS-generated ESI maps produced by NOAA used polygon patterns instead of symbols for display of the biological resource data because problems in icon placement, sizing, and resolution made them difficult to use on screen images and required time-consuming manual placement for map output.

However, users of the ESI maps strongly encouraged a return to symbol use, and the later ESI maps use both polygons to indicate the spatial distribution and symbols to indicate the resource categories and groupings present. A symbol set for mapping applications has been developed and is included in Figure 6.

Resources that have widespread distribution are indicated by listing them in a box labeled "common throughout." This approach will be especially important for narrow river corridors or in complicated backwater habitats, where resources tend to be concentrated and displaying all resources present will make the map unreadable. Macros can be written to automatically select the data to be included in the "common throughout" box by specifying a percent coverage of the habitat on the map. For example, all resources which are present in more than 50 percent of the water area in a river could be placed in the "common throughout" box and the polygon coverages not displayed. If different water bodies are defined in the database (e.g., main river stem versus backwater lakes, based on NWI classifications) then multiple "common throughout" groupings could be used, such as "common throughout river" and "common throughout backwater lakes." This convention greatly improves the readability of the map, yet maintains access to the data by the map user.

Figure 6. Symbols for representation of the biological and human-use resources.

Human-Use Symbols

Most human-use features are represented as points and identified with a symbol. Human-use symbols currently displayed on ESI maps are shown in Figure 6. The symbol for a human-use feature is placed offset from the feature with a leader line drawn from the symbol to the feature. The boundaries of parks, preserves, reserves, and refuges are drawn using a dashed line, and the site name is located under the appropriate symbol.

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APPENDIX

Data table structure suggested for the data to be collected by the basin commissions.

WATER INTAKES

Reference no.	User reference number
Permittee/water user	Company or entity holding the permit
Water Use	Reason for withdrawal (potable water, Power generation, industrial use)
24-hr emergency phone	Number for emergency calls
Waterbody	Waterbody in which the intake is located
River mile	River mile location of intake (if there are river miles on the river)
County	County in which the intake is located
Latitude	Latitude of intake (from data sources)
Longitude	Longitude of intake (from data source)
Township	Township location of the intake
Range	Range location of the intake
Section	Section location of intake
Descriptive location	Description of where the intakes located (distance from shore, reference to local landmarks. Aids in responder finding the intake
Street	Street address of facility
City	City of facility
State	State of facility
Zip code	Zip code of facility
Contact Person	Contact person named on the application
Depth of Intake	Depth of intake in waterbody
Withdrawal MGY	Average annual withdrawal rate
Season	Time period during which water is being withdrawn.
Storage capacity	Duration that the facility as water reserves for should the intake be shut down

Admin. Address	Address of administrative offices
Contact Phone	Phone number for non-emergency situations
Permit #	Permitting agencies permit number
Data source	Where the data was obtained from. If information was from the facility need only enter FACILITY
Date	Date of information from the data source, not the date it was entered into the database
Comments	Any additional information available about the facility, such as alternate intake sources, better locational information, population served, etc.

ENVIRONMENTAL SENSITIVE AREAS

Reference no.	User reference number
Site category	The category into which the area falls (State park, national park, wildlife refuge, etc.)
Site name	The full name of the area
State	State in which the area is located
County	County in which the area is located
Township	Provides the location of the area by township
Range	Provides the location of the area by range
Section	Provides the location by section where appropriate
Waterbody	The major waterbody on which the area is located, when known
Acreage	Acreage of the area. This can be calculated by the GIS once the area has been digitized
Managing agency	The agency or group responsible for the area
Contact	Name of the person to contact responsible for the area
Address	Address of the contact
Phone	Phone number of the contact
Source	Source of the information for the area. There may be more than one entry
Date	The date of the source information for the area, NOT the date it was entered
Comments	Any additional information available for the area

MARINAS

Reference no.	User reference number
Marina name	Name of the marina
Owner	Name of the marina owner
Street Address	Street Address of the marina
City	City in which the marina is located
State	State in which the marina is located
Zip code	Zip code of the marina
County	County in which the marina is located
Township	Township location of the marina
Range	Range location of the marina
Section	Section location of the marina
Latitude	Latitude of the marina, in decimal degrees to at least 4 decimal places
Longitude	Longitude of the marina, in decimal degrees to at least 4 decimal places
Telephone	Telephone number of the marina owners
24-hr emergency phone	24 hour emergency contact number for the marina
Waterbody	The major waterbody on which the marina is located
River mile	The river mile location of the marina, where available
Riverbank	Which bank of the river the marina is on
Descriptive location	A descriptive location of the marina so that a responder can locate it
Slips	Number of slips in the marina
Boat ramps	Number of boat ramp lanes in the marina
Source	Source of the information for the marina
Date	Date of the source information, not the date it was entered
Comments	Any additional information about the marina that is available, such as hoists, fuel storage, etc.

BOAT RAMPS

Reference no.	User reference number
Boat ramp name	Name of the boat ramp
Owner	Name of the boat ramp owner
Street Address	Street address of the boat ramp owner
City	City address of the boat ramp owner
State	State address of the boat ramp owner
Zip code	Zip code of the boat ramp owner
County	County in which the boat ramp is located
Township	Township location of the boat ramp
Range	Range location of the boat ramp
Section	Section location of the boat ramp
Latitude	Latitude of the boat ramp, in decimal degrees to at least 4 decimal places
Longitude	Longitude of the boat ramp, in decimal degrees to at least 4 decimal places
Telephone	Telephone number of the boat ramp owners
Waterbody	The major waterbody on which the boat ramp is located
River mile	The river mile location of the boat ramp, where available
Riverbank	Which bank of the river the boat ramp is on
Descriptive location	A descriptive location of the boat ramp so that a responder can locate it
Source	Source of the information for the boat ramp
Date	Date of the source information, not the date it was entered
Comments	Any additional information about the boat ramp that is available such as surface and width of ramp

TRIBAL INDIAN LANDS

Reference no.	User reference number
Name	The full name of the land
State	State in which the land is located
County	County in which the land is located
Township	Provides the location of the land by township
Range	Provides the location of the land by range
Section	Provides the location by section where appropriate
Waterbody	The major waterbody on which the land is located, when known
Acreage	Acreage of the land. This can be calculated by the GIS once the land has been digitized
Tribe	Name of the tribe to whom the land belongs
Contact	Name of the person to contact responsible for the land
Address	Address of the contact
Phone	Phone number of the contact
Source	Source of the information for the land. There may be more than one entry
Date	The date of the source information for the land, NOT the date it was entered
Comments	Any additional information available for the tribal lands

NATURAL HERITAGE DATA

Reference no.	User reference number
State	State in which the intake is located
County	County in which the intake is located
Latitude	Latitude of intake (from data sources)
Longitude	Longitude of intake (from data source)
Township	Township location of the intake
Range	Range location of the intake
Section	Section location of intake
Common name	Common name of the species
Genus, species name	Genus and species name of the species
Species category	Category of the species (Bird, fish, plant, etc.)
Species status	Protected status of species (Threatened, endangered, etc.)
State or Federal	State or Federal protection
Species seasonality	Field to link to a Life History table for the species
Source	Source of the data
Date	Date of the source data, in this case date of the species siting

LIFE HISTORY

Genus, species name	Genus and species name of the species
Species seasonality	Field to link to the Natural Heritage Data
Month	Month the species is present. There should be one record for each month the species is present
Lifestage	Lifestage of the species during this month
Breeding activity	Breeding activity of the species during this month